Tsunami Warnings for Maritime Services

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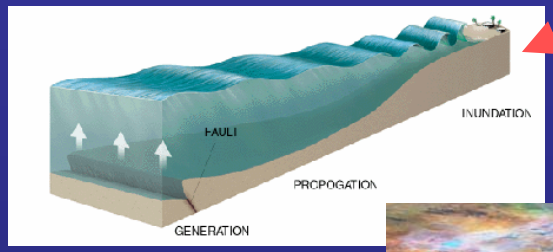
The Threat

- Hard to predict
- Hard to characterise
- Very fast moving
- Difficult to monitor
- Hard to warn
- Challenge to educate

Sources of Tsunami

- Earthquakes along subduction zones
- Undersea landslides
- Volcanoes
- Meteorites



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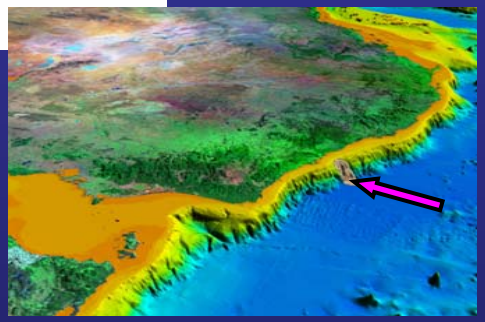
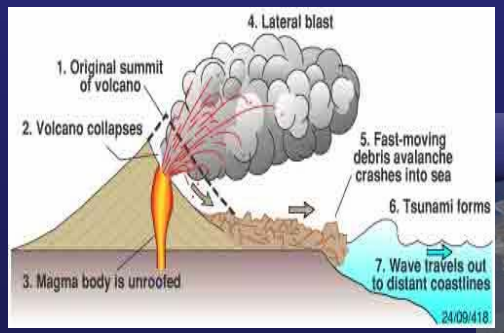
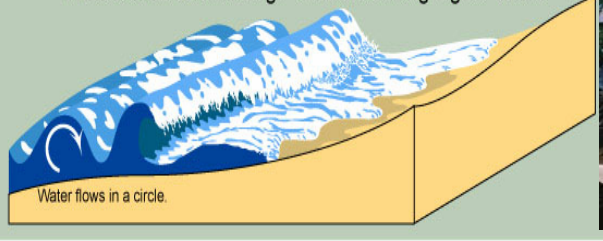




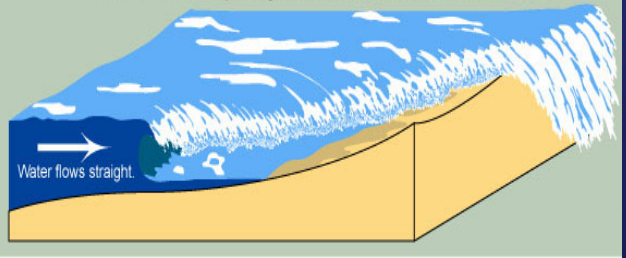
Tsunami are not like normal wind waves at the beach

Tsunamis are often no taller than normal wind waves, but they are much more dangerous.

Wind waves come and go without flooding higher areas.



Tsunamis run quickly over the land as a wall of water.



Even a tsunami that looks small can be dangerous!

Any time you feel a large earthquake, or see a disturbance in the ocean that might be a tsunami, head to high ground or inland.

Tsunami Facts

- Small in open ocean (2-10cm) travelling 900km/h
- Become large as shoal and slow to 50km/h
- More powerful than same size wind wave on beach
- Relatively small waves (20-70cm amplitude) ca
  cause damage
- First wave not necessarily the largest
- Not always preceded by drop in “tide”
- Not all undersea earthquakes generate
- Not tidal, more like powerful surge

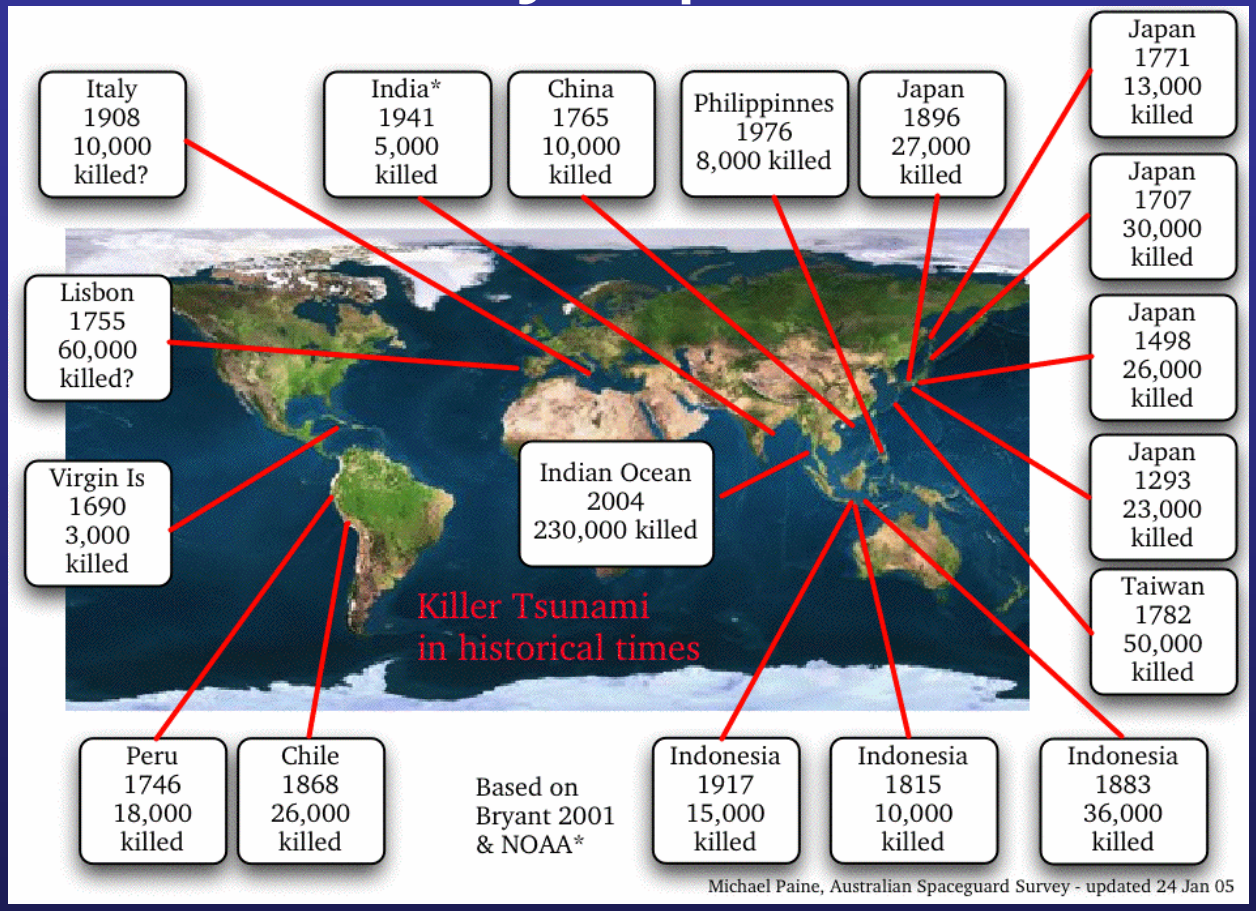
Tragedy…26 December 2004

~238,000 Lives lost

14,100 Missing

1,126,000 Displaced

Historically – prior to 2004

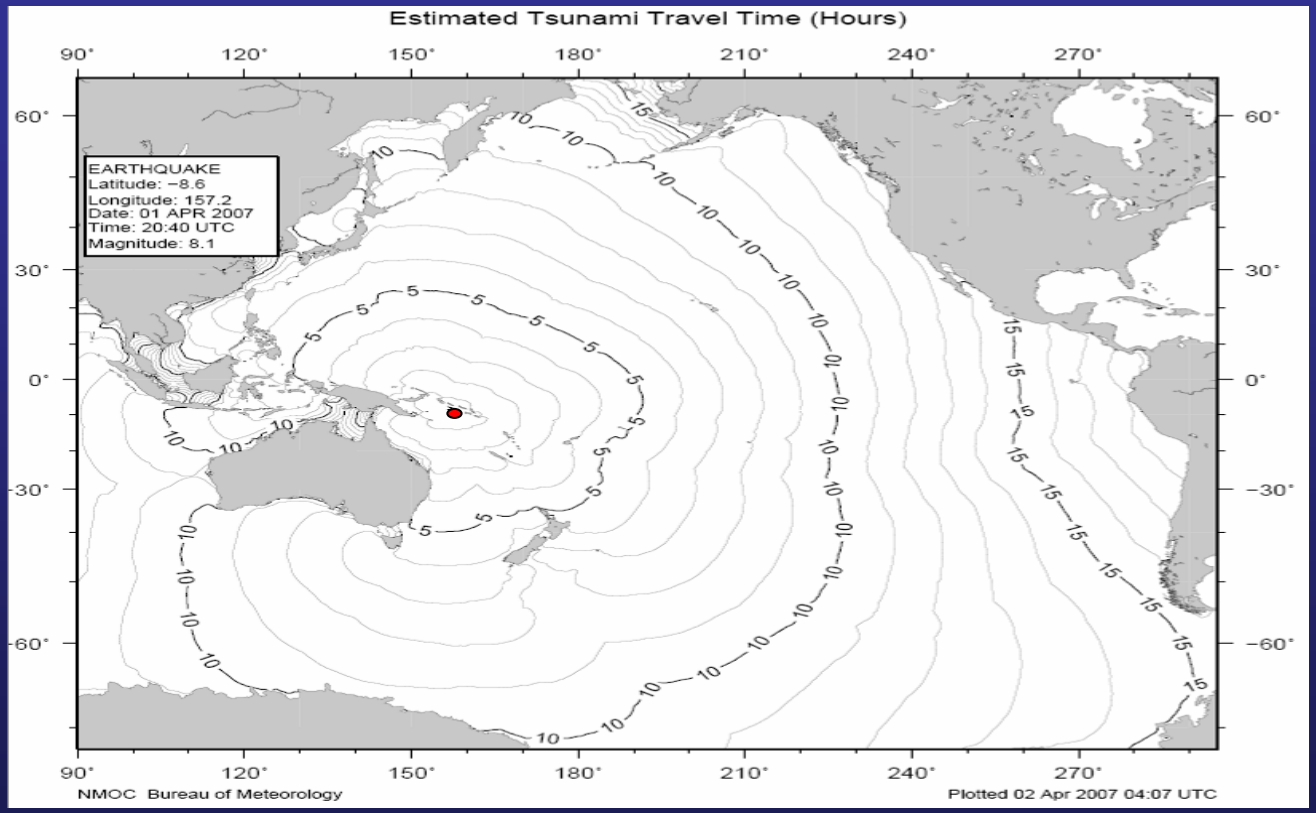


Level of Preparedness prior to 2004

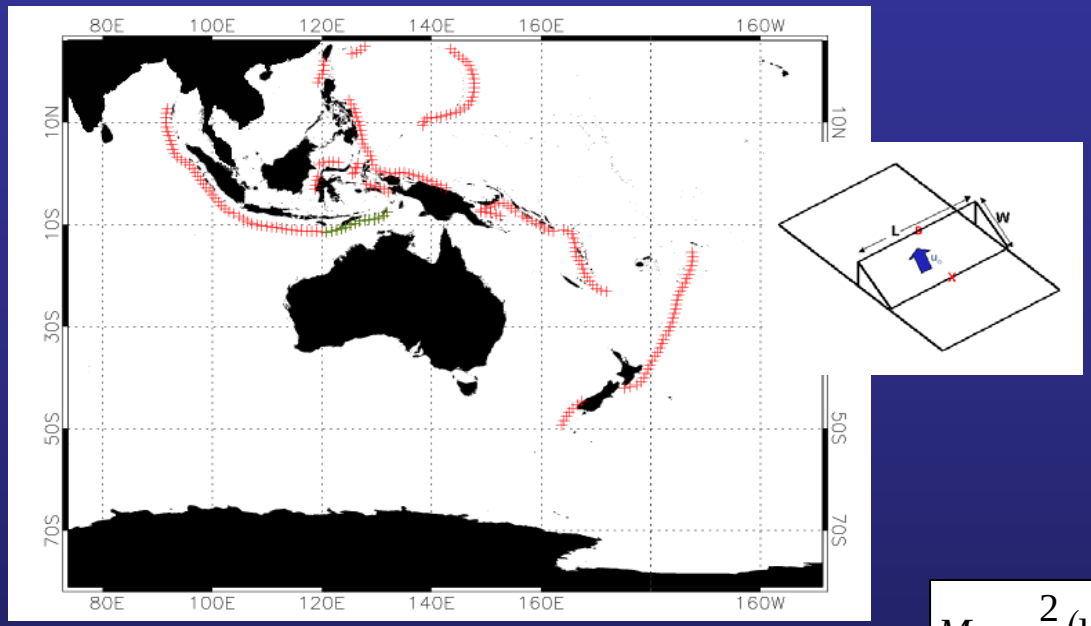
- Limited information and warning infrastructure
  - Limited access to earthquake information
  - No sea level data in “real-time”
  - No forecasting capability
  - No recognised tsunami warning centres
  - No national contacts to pass on warnings to
  - No tailored communication systems/procedures to advise public
  - Little/no community education, awareness or preparedness

Previously Limited Service:

No height information – possibility of false alarms



Now…Tsunami Forecast Models

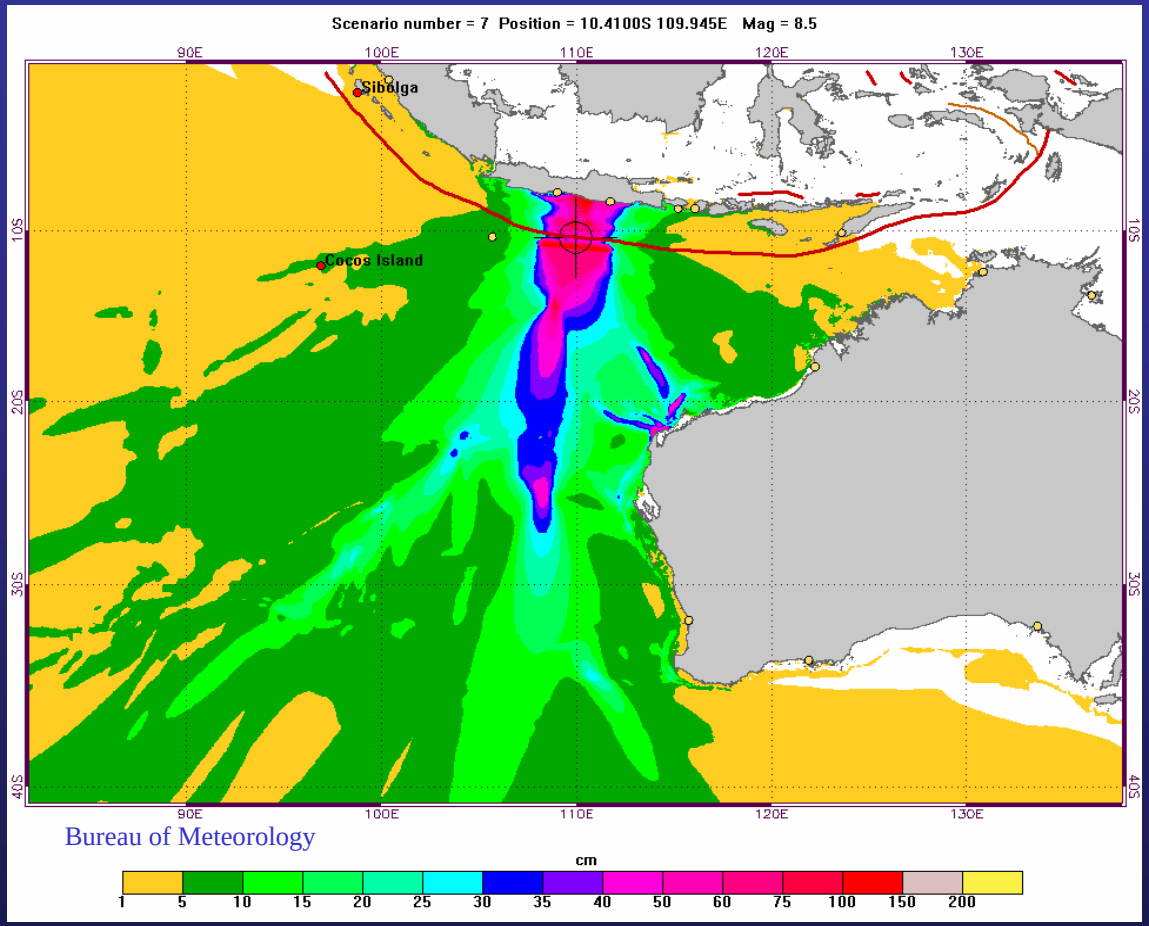


M_w	Width (km)	Length (km)	u_o (m)	Dip (°)	Rake (°)	Depth (km)
7.5	50	100	1	25	90	10
8	65	200	2.2	25	90	10
8.4	80	400	3	25	90	10
9	100	1000	8.8	25	90	10

$$M_w = \frac{2}{3}\left(\log_{10} M_o - 9.1\right)$$

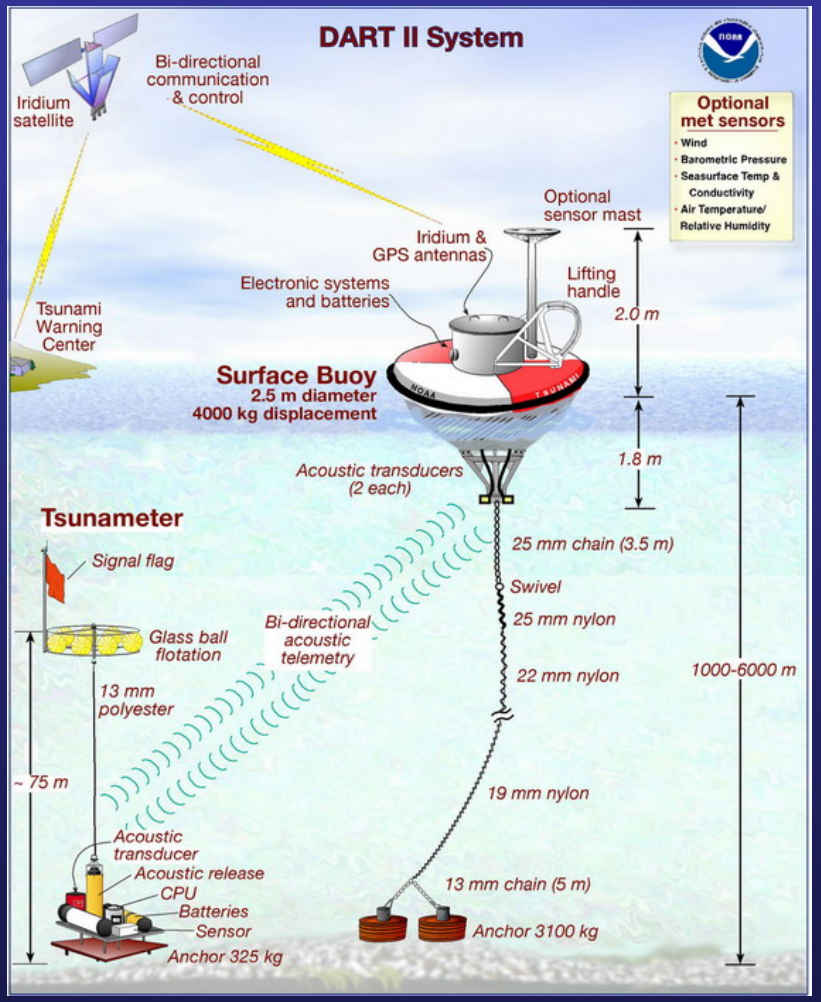
$$M_o = \mu L W u_o$$

Tsunami Scenarios – provide more specific information on actual threat



Expanded Coastal Sea Level Monitoring

Deep Ocean Tsunami Detection Buoys

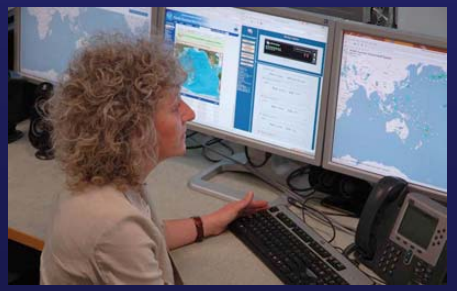


International Coordination of Tsunami Warning Systems

- An Intergovernmental Coordination Group (ICG) has been established under the auspices of UNESCO's Intergovernmental Oceanographic Commission (IOC) for each affected ocean basin:
  - Indian
  - Pacific
  - Caribbean
  - NE Atlantic & Mediterranean

Tsunami Warning & Advisory Providers

- National Tsunami Warning Centres (NTWCs) have been nominated by IOC Member States
  - Sovereign responsibility for warning their communities
  - Variation in capabilities
    - Able to determine tsunami threat independently; or
    - Interpret tsunami threat information received from regional tsunami warning centres and disseminate as warnings to the public



Tsunami Warning & Advisory Providers

- Regional tsunami warning centres provide advice to NTWCs to act upon
- Pacific
  - Pacific Tsunami Warning Centre (Hawaii) since 1960s following 1960 Chile earthquake
  - Supported by Japan Meteorological Agency (Tokyo)

Indian Ocean Regional Tsunami Watch Providers

- PTWC and JMA presently provide Interim Advisory Service (IAS)
- India, Australia, Indonesia will replace IAS in 2011 with more detailed RTWP service
- Malaysia, Iran and Thailand are also developing RTWP capability

Global Harmonisation

- Tsunami warning system established in the Pacific since 1960s
- Since destructive Indian Ocean Tsunami 2004, tsunami warning systems have been developed in 3 other ocean basins
- The IOC has established the Tsunami & Other Ocean Hazards Related to Sea Level Warning & Mitigation Systems (TOWS) Working Group and a number of task teams (meeting Dec10) to harmonise and standardise terminology, warning formats and procedures as far as possible between the oceans

Example message to shipping from AMSA(1)

P 042237Z AUG 2010
FM RCC AUSTRALIA
TO POR
RCC AUSTRALIA/VIC
COASTWATCH (AMSOC)(BPC) CANBERRA
HQJOC JCC METOPS
MAROPS
HQJOC
CTG 627.0
MRCC PORT MORESBY
MRCC PORT MORESBY
MRCC PORT MORESBY
PORT MORESBY RADIO
EMA
HQNORCOM
JOICAUST
NAVAREA VIII COORDINATOR
NAVAREA XI COORDINATOR
JOINT AUSTRALIAN TSUNAMI WARNING CENTRE - JATWC

Example message to shipping from AMSA(2)

BT
UNCLAS
SIC ICA/LTJ
SUBJ: TSUNAMI WARNING
AUSSAR 2010/5008
1. VIC PLEASE ACTIVATE DSC AND TRANSMIT FOLLOWING URGENCY BROADCAST ON RECEIPT AND 6 HOURLY UFN TO AREA:
NW CORNER LAT 4S
NW CORNER LONG 147E
EXTENT OF LAT SOUTH 6.
EXTENT OF LONG EAST 6.

2. PORT MORESBY RADIO PLEASE BROADCAST FOLLOWING URGENCY MESSAGE ON HF/VHF ON RECEIPT AND HRLY UFN TAKING CARE TO AVOID MUTUAL INTERFERENCE WITH VIC AND OTHER COAST RADIO STATIONS ON HF. OTHER COAST RADIO STATIONS PLEASE NOTE CONTENT OF FOLLOWING URGENCY FOR YOUR INFORMATION ONLY.

3. PASSED TO POLICE SAR COORDINATORS FOR BROADCAST BY LOCAL COAST STATIONS AND FISHING COMPANIES ON VHF AND 27MHZ (27.88).

Example message to shipping from AMSA(3)

4. FLWG IS TEXT OF URGENCY MSG:
/BEGINTEXT
PAN PAN
FM RCC AUSTRALIA 042237Z AUG 2010 AUSSAR 2010/5008

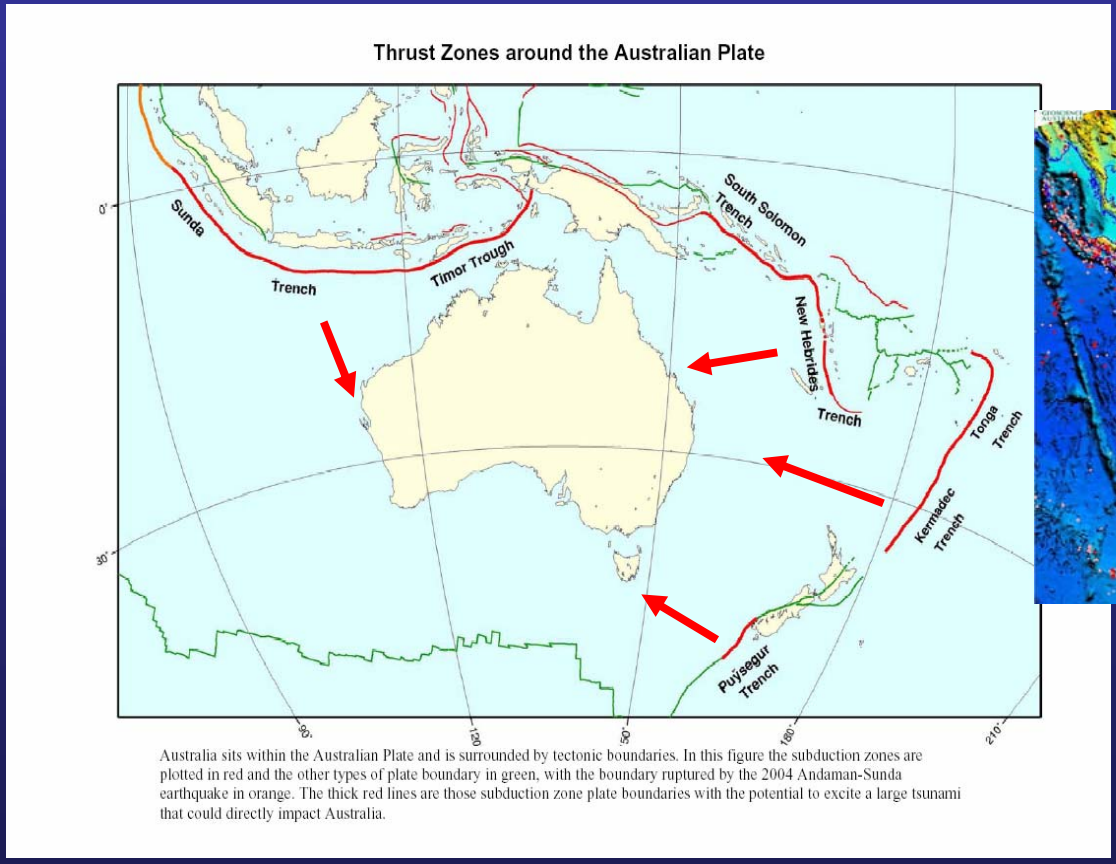
TSUNAMI WARNING
EARTHQUAKE OF MAGNITUDE 7.0 HAS OCCURRED IN POSITION 06 03 S 150 48E AT 042202UTC AND MAY GENERATE LOCAL TSUNAMI.
WITHIN 100 KILOMETRES OF EARTHQUAKE EPICENTRE.
SHIPS OPERATING WITHIN THE AFFECTED AREA ARE REQUESTED TO RELAY THIS INFORMATION VIA VHF CHANNEL 16.
/ENDTEXT

5. THIS MSG IS ALSO BEING BCAST ON INMARSAT C SAFETYNET.

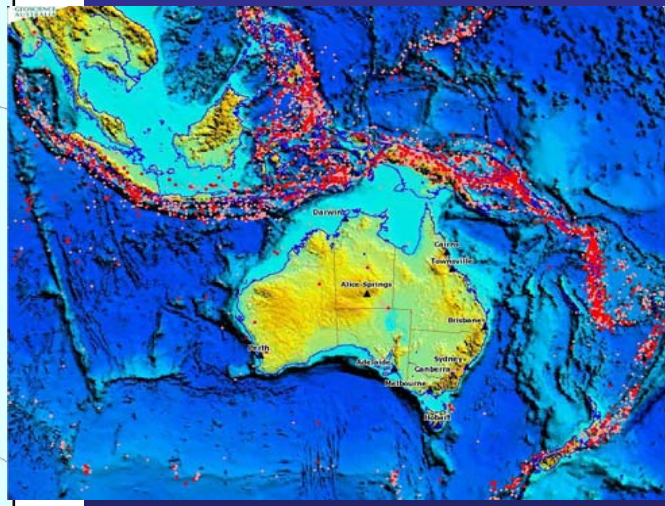
Community Response Advice in Australia

- Marine environment and immediate foreshore threat
  - Move out of the water and stay away from the waterfront of harbours, coastal estuaries, rock platforms and beaches.
  - Boats in harbours, estuaries and in shallow coastal water should return to shore. Secure your boat and move away from the waterfront.
  - Vessels already at sea in deep water should remain well offshore (water deeper than 25m) until further advised.
  - Do not go to the coast to watch the tsunami.

Australia's Vulnerability



Australia sits within the Australian Plate and is surrounded by tectonic boundaries. In this figure the subduction zones are plotted in red and the other types of plate boundary in green, with the boundary ruptured by the 2004 Andaman-Sunda earthquake in orange. The thick red lines are those subduction zone plate boundaries with the potential to excite a large tsunami that could directly impact Australia.



Subduction Zones

Australia's Vulnerability

- New South Wales, 1960

SYDNEY HARBOUR IN CHAOS FROM QUAKE WAVE

SYDNEY. — Tidal waves generated by the earthquakes in Chile smashed into the New South Wales coastline yesterday.

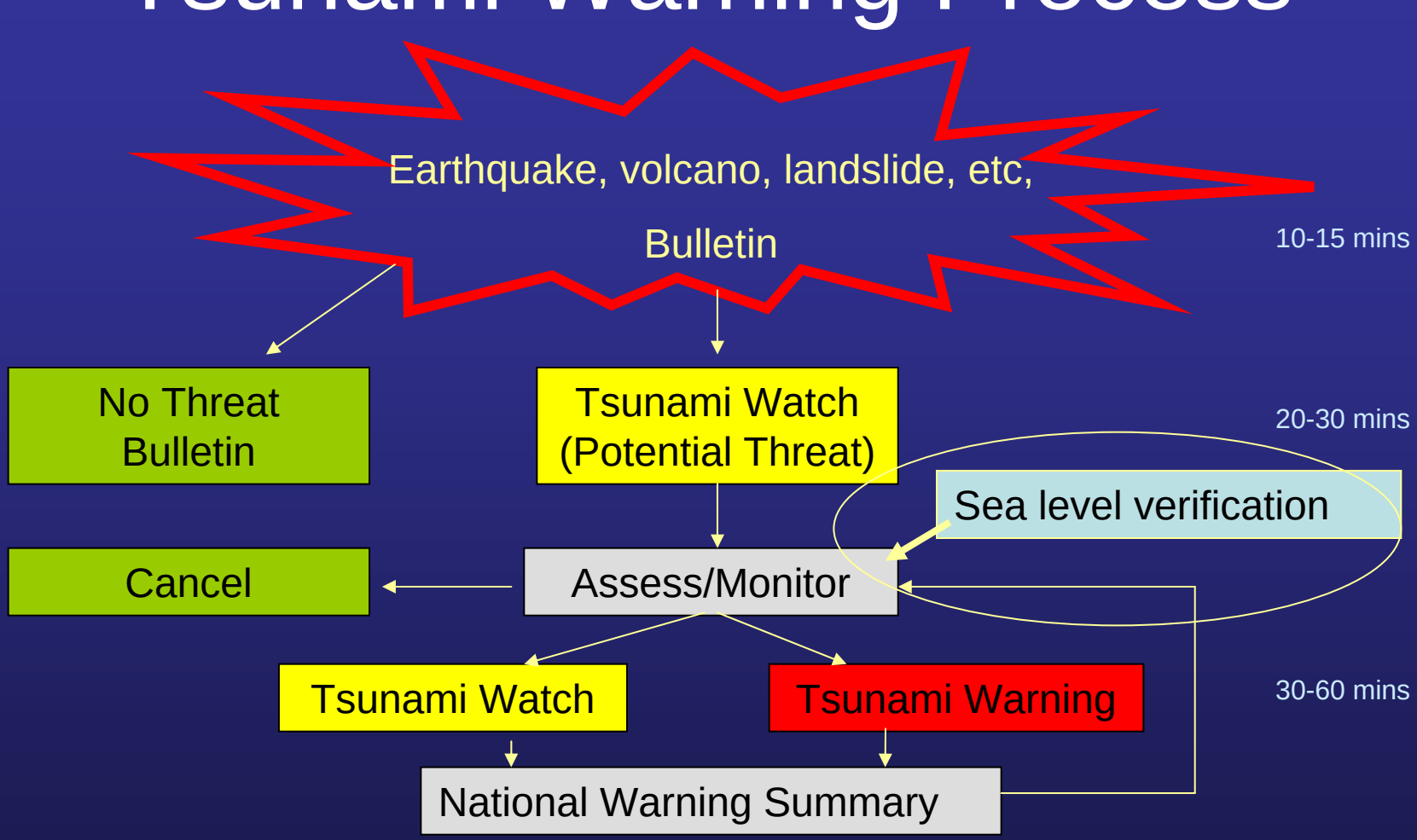
AIR PILOT SEES BEACH DISAPPEAR

MELBOURNE. — Salmon spotting pilot Dick Ritchie yesterday saw Three-Mile Beach, Wilson's Promontory, "disappear" while

Joint Australian Tsunami Warning Centre (JATWC)

- Geoscience Australia
  - Seismic monitoring and analysis
- Bureau
  - Sea level monitoring & forecasting
  - Tsunami assessment
  - Warning distribution to public, media, emergency authorities

Tsunami Warning Process



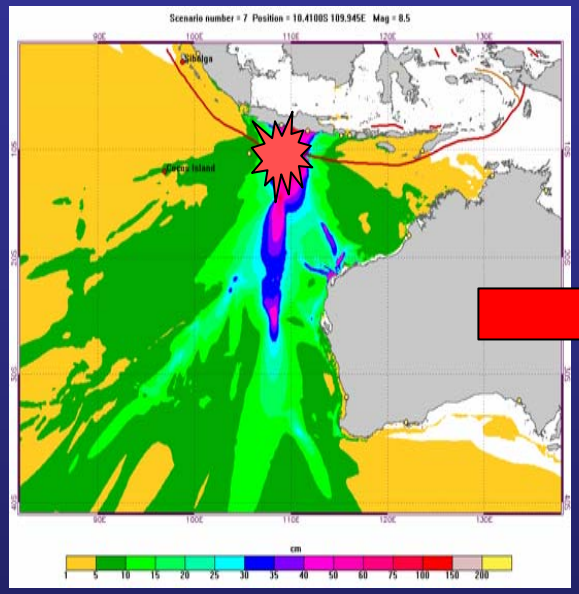
Tsunami Warnings in Australia

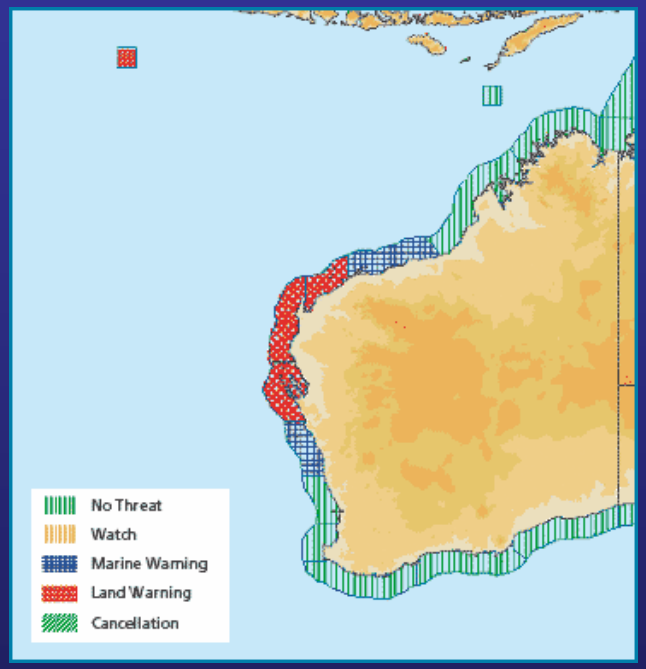
MESSAGES: TYPES & PURPOSE

National No Threat Bulletin	To advise people that the earthquake has been assessed and that no tsunami threat exists
National or S/T Watch	To advise people that a tsunami threat may exist and that they should look out for further updates
S/T Warning	To advise people that a tsunami threat does exist and to advise them of the action they should take
National Warning Summary / Status	To provide the public, media and emergency authorities with a national status summary
Event Summary	To provide the public, media, emergency authorities & Govt with summary information that can be used in post event analyses

S/T=State/Territory

Tsunami Warnings in Australia





- Categories of threat
- Coastal zones
- Arrival times
- Response advice

www.bom.gov.au

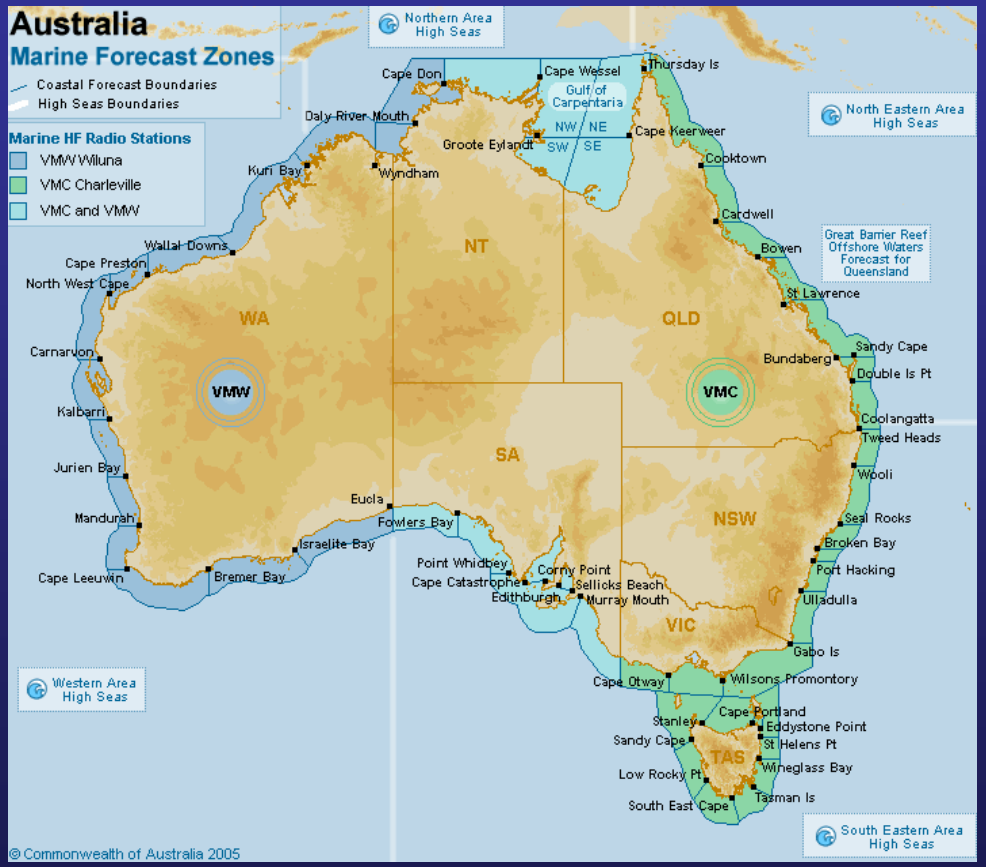
1300 TSUNAMI

(1300 878 6264)

Tsunami Warnings in Australia: Threat Levels

Coastal Zones

Threat areas defined using pre-existing zones for Coastal Waters Weather Forecasts



Example:

Broken Bay to Port Hacking, including Sydney

Tsunami Warnings Format

MESSAGES: LAYOUT & CONTENT

Product Identifier	Identify type product/auto notifier
Media Instructions	How urgently should be broadcast. Use of Standard Emergency Warning Signal (SEWS) or not
Message Title and Issue Time	Type, date / time and number sequence of message
Headline Message	Key message; eg. No Threat, Potential Threat, Threat
Summary	What, where and when the threat is
Threat Information	Level of Threat , Coastal areas affected, time of Arrival
Community Response Advice	What action people should take
Next Update Time	When the next update will be issued
Where Public can get Further Information	Web and telephone details for further / latest information

S/T=State/Territory

Example

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TSUNAMI THREAT TO LOW-LYING COASTAL AREAS AND THE MARINE ENVIRONMENT

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SUMMARY:

Tsunami warning for parts of Western Australia

LAND Threat

- For low-lying coastal areas from Kalbarri to Cape Preston, including Denham, Carnarvon, Coral Bay, Exmouth and Onslow, there is a threat of MAJOR LAND INUNDATION, FLOODING, DANGEROUS WAVES AND STRONG OCEAN CURRENTS for several hours from 7:45 PM WST on Sunday
- People in affected areas are strongly advised by FESA to go to higher ground or at least one kilometre inland

MARINE Threat

- For the marine environment from Cape Preston to Wallal, including Dampier and Port Hedland, there is the possibility of DANGEROUS WAVES, STRONG OCEAN CURRENTS, AND SOME LOCALISED OVERFLOW ONTO THE IMMEDIATE FORESHORE for several hours from 8:00 pm WST on Sunday
- For the marine environment from Jurien Bay to Kalbarri, including Geraldton, there is the possibility of DANGEROUS WAVES, STRONG OCEAN CURRENTS, AND SOME LOCALISED OVERFLOW ONTO THE IMMEDIATE FORESHORE for several hours from 8:15 pm WST on Sunday

For all threatened areas, people are advised to get out of the water and move away from the immediate water's edge

For latest and further information call 1300 TSUNAMI (1300 878 6264) or visit www.bom.gov.au

Next update will be issued by 6:45pm WST on Sunday 30 September 2007

Community Response Advice in Australia

- Major land inundation threat
  - Take only essential items that you can carry including important papers, family photographs and medical needs.
  - Go to higher ground, at least ten metres above sea level, or if possible move at least one kilometre away from all beaches and the water's edge of harbours and coastal estuaries.
  - It will be in your own interests to walk to safety if possible to avoid traffic jams.
  - If you cannot leave the area take shelter in the upper storey of a sturdy brick or concrete multi-storey building.

Community Response Advice in Australia

- Marine environment and immediate foreshore threat
  - Move out of the water and stay away from the waterfront of harbours, coastal estuaries, rock platforms and beaches.
  - Boats in harbours, estuaries and in shallow coastal water should return to shore. Secure your boat and move away from the waterfront.
  - Vessels already at sea in deep water should remain well offshore (water deeper than 25m) until further advised.
  - Do not go to the coast to watch the tsunami.